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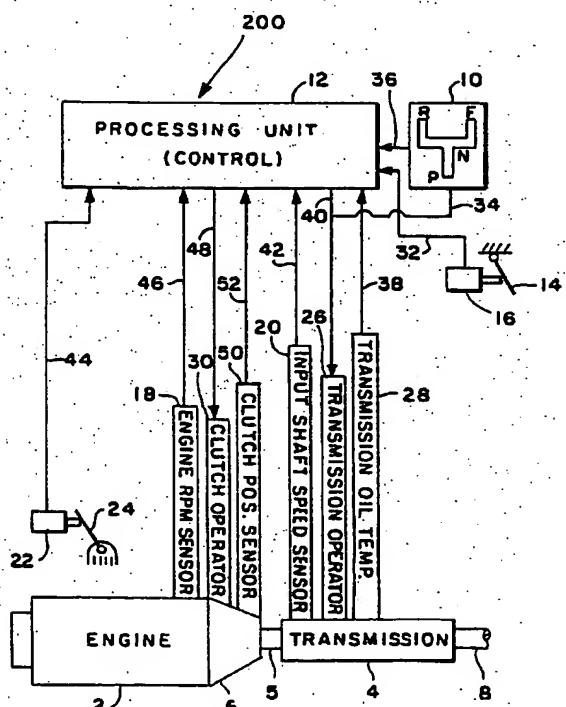
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## 54 Incipient clutch control systems.

57 An automatic clutch control system (200) is provided featuring programs for establishing optimum clutch engagement starting position (CPO) under varying operating conditions. The programs include the steps of both slow and rapid clutch engagement and preferably the storage of the (CPO) determined as a fault signal whenever its fractional relationship to the previously stored optimum clutch engagement starting position (CPN) exceeds a predetermined fraction (C6) that is less than one.



## INTRODUCTION

This invention relates generally to an automatic clutch control system for use between a vehicle engine and a transmission and more particularly to a control system that automatically positions the clutch for its most effective or incipient torque engagement starting position according to operating parameters such as engine speed, oil temperature and clutch wear.

## BACKGROUND OF THE INVENTION

Interest in improving vehicle performance has increased dramatically in recent years with one result being the development of a variety of automatic systems for maintaining and controlling various engine parameters.

Of particular interest in the recent past has been the desire to position the incipient or engagement starting position of the clutch so that it is optimized according to particular engine conditions such as engine speed, transmission oil temperature and clutch wear existing at the time. For example, it may be desired that the disengaged position be advanced a predetermined amount toward the engaged position to account for wear or in a direction away from the engaged position in the case of increasing transmission oil temperature or higher engine speeds.

One example of a method for controlling friction clutch operation is described in published British application GB 2231116A, the disclosure of which is incorporated herein by reference. Here a variety of engine parameters are employed to apply correction factors to the primary parameters of angular movement for optimizing clutch engagement.

Another example of a clutch control system is described in United States patent 4,678,069, the disclosure of which is incorporated herein by reference. Here, transmission oil temperature and transmission input shaft speed are both used as correction factors for adjusting the clutch starting position.

Yet another example of an automatic clutch control system is disclosed in United States patent 5,029,678, the disclosure of which is incorporated herein by reference. Here, engine speed, transmission input shaft speed and amount of accelerator pedal depression are used to adjust the clutch's engagement starting position.

The system of the present invention utilizes sensed parameters of engine speed, transmission input shaft speed, actual and predetermined clutch position in conjunction with optional sensed or calculated parameters such as rate of change of transmission input shaft speed, transmission oil temperature, rate of change of clutch position in a control system for optimizing the clutch engagement start position under various operating conditions that uniquely utilize

two different rates of clutch engagement as part of a program for determining optimum clutch incipient starting position. The system of the invention further preferably establishes and stores fault codes in memory indicative of when the incipient clutch position for particular sensed operating conditions (when the transmission is not in neutral) differs by more than a predetermined fraction that is less than one.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a system for determining optimum incipient or engagement starting position for a motor vehicle transmission clutch under various operating conditions.

It is another object of this invention to provide a system for controlling the incipient or engagement starting position of a motor vehicle clutch that utilizes two different rates of engagement of the clutch as part of the process for determining the optimized or incipient position for the clutch under various operating conditions.

It is still another object of this invention to provide a fault code in a system for controlling optimum clutch engagement starting positions for various operating conditions when the optimized starting position for when the transmission is not at neutral differs by more than a predetermined fraction less than one from that for the same set of operating conditions when the transmission is at neutral.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a clutch control system 200 of the invention;  
 FIGURE 2 is a block diagram of an initial portion of one program by which the optimal position at neutral is established;  
 FIGURE 3 is a block diagram of a continuation of the program of FIGURE 1;  
 FIGURE 4 is a block diagram of the final portion of the program of FIGURES 2 and 3;  
 FIGURE 5 is a block diagram of an initial portion of another program for determining the incipient clutch position which is the same as in FIGURE 1;  
 FIGURE 6 is a block diagram of a program portion subsequent to the program of FIGURE 5; and  
 FIGURE 7 is a block diagram of a final portion of the program of FIGURE 6 and which is the same as the program portion in FIGURE 4.

## DESCRIPTION OF SOME PREFERRED EMBODIMENTS

In FIGURE 1, engine 2 is selectively coupled to input shaft 5 of transmission 4 by coupling or clutch



C3) which is then stored and used in the program beginning at the step referenced by numeral 119 in FIGURE 3.

If the initial (CPO) is greater than (C4) (reference numeral 119), unit 12 issues a command signal 48 instructing clutch operator 30 to engage the clutch rapidly. In the step referenced by numeral 121 and, if the actual clutch position (CPA) is less than (CPO) in the step referenced by numeral 123, the process is repeated. If (CPO) is greater than (C4) in the step referenced by numeral 123, unit 12 issues a command signal 48 to clutch operator 30 instructing it to engage the clutch slowly (reference numeral 125) after which the transmission input shaft speed is measured (reference numeral 127) and, if it has not increased, the process is repeated and, if the shaft speed has increased, the actual clutch position is read (reference numeral 129) and unit 12 determines (CPO) as a function of (CP1 - C3).

The last portion of the first program hereinbefore described is set forth in FIGURE 4 in which unit 12 determines the fraction (C5) from the equation

$$(C5) = \frac{CPN - CPO}{CPN}$$

(reference numeral 149) which is then compared to (C6) (a predetermined fraction less than one) and, if (C5) is less than (C6), (CPO) is determined from the equation (CPO) = (CP1-C3) (reference numeral 159) which is then stored (reference numeral 161) and the process then returns to the step referenced by numeral 101 in FIGURE 1.

If (C5) is greater than (C6) (reference numeral 151) in FIGURE 4, it is stored as a fault code (reference numeral 153) after which (CPO) is determined from the equation (CPO) = (1-C6) (CPO) (reference numeral 155) which is then stored (reference numeral 157) and the program returns to its initial starting point at reference numeral 101 in FIGURE 1.

A second program of the invention for establishing the incipient (CPO) is set forth in FIGURES 5-7 with reference numerals carrying the subscript "a".

The steps referenced by the first portion of the second program referenced by numerals 101a through 116a in FIGURE 1 for determining (CPO) from (CPN) at neutral are the same as the steps referenced by numerals 101 through 116 in FIGURE 1 for the first program and are therefore not repeated here.

The second portion of the second program is shown in FIGURE 6 in which it is determined if the transmission input shaft speed (N<sub>T</sub>) (reference numeral 118a) is less than some predetermined low speed (C7) and, if not, the then the process is repeated and, if yes, it is determined whether the (CPO) determined by the step referenced by numeral 113a

(FIGURE 5) is greater than a predetermined clutch position (C4) (reference numeral 119a) and, if not, a calibrating procedure is entered into at reference numeral 135a in which unit 12 issues a command signal 48 to clutch operator 30 instructing it to engage the clutch slowly after which unit 12 determines whether the transmission input shaft speed (N<sub>T</sub>) is greater than a predetermined low speed (C7) (reference numeral 139a) and, if not, the process is repeated, and, if yes, its value is read as (CP1) (reference numeral 141a) and (CPO) is determined by unit 12 from the equation (CPO) = (CP1 - C3) after which it is stored (reference numeral 145a) and used as the value of (CPO) at the step referenced by numeral 119a.

If (CPO) is greater than C4 (reference numeral 119a), unit 12 issues a command signal 48 instructing clutch operator 30 to engage the clutch rapidly (reference numeral 121a) after which unit 12 determines whether (CPA) is greater than (CPO) and, if not, the process is repeated, and, if so, unit 12 then issues a command signal 48 instructing the clutch to engage slowly (reference numeral 125a). It is then determined by unit 12 whether the transmission input shaft speed (N<sub>T</sub>) is greater than a predetermined low speed (C7) and, if not, the process is repeated and, if yes, unit 12 then determines whether the transmission input shaft speed (N<sub>T</sub>) is greater than the predetermined low speed (C7) and, if not the process is repeated.

If N<sub>T</sub> is greater than (C7) (reference numeral 127a), the actual clutch position (CP1) is read (reference numeral 129a) and unit 12 then determines (CPO) from the equation (CPO) = (CP1-C3) (reference numeral 131a) which is used as the starting position (reference numeral 147a) of the last portion of the second program shown in FIGURE 7.

The program portion denoted by reference numerals 147a-161a in FIGURE 7 is the same as the program portion denoted by reference numerals 147-161 in FIGURE 4 previously described and is therefore not repeated here. The (CPO) finally determined at reference numerals 157a or 161a is used as input information to the initial step of the second program referenced by numeral 101a in FIGURE 5.

It can readily be seen that programs in accordance with the present invention for establishing the optimum clutch engagement starting position (CPO) include the steps of both slow and rapid engagement of the clutch in the determination process as well as preferably storing the fractional relationship between the determined (CPO) and the optimum neutral clutch engagement starting position (CPO) whenever the fraction exceeds a predetermined fraction (C6) that is less than one.

## Claims

1. An automatic clutch control system (200) for optimizing the clutch engagement starting position for coupling a vehicle engine (2) to a transmission input shaft (5), said system including an information processing unit (12) having means for receiving a plurality of input signals including (1) a signal indicative of engine speed (46); (2) a signal (52) indicative of actual clutch position, (3) a signal (42) indicative of transmission input shaft speed and, (4) a signal (36) indicative of whether or not the transmission is in a neutral position, said processing unit (200) including means for processing said input signals according to a predetermined program for determining the optimum clutch engagement starting position and for issuing an output command signal (48) instructing a clutch operator (30) to move the clutch thereto, and said program including the step of engaging the clutch slowly in the event that, subsequent to engaging the clutch rapidly, the unit determines that the actual clutch position is greater than a predetermined optimum clutch engagement starting position.
2. The system (200) of claim 1 wherein the information processing unit (12) is further operative to reduce the clutch engagement starting position by a predetermined amount whenever the change from the previous clutch engagement starting position when expressed as a fraction of said position is greater than a predetermined fraction that is less than one.
3. An automatic clutch control system (200) for optimizing the clutch engagement starting position for coupling a vehicle engine to a transmission input shaft, said system including an information processing unit (12) having means for receiving a plurality of input signals including (1) a signal (46) indicative of engine speed ( $N_E$ ); (2) a signal (52) indicative of actual clutch position (CPA); (3) a signal (42) indicative of transmission input shaft speed ( $N_T$ ) and; (4) a signal (36) indicative of whether or not the transmission is in a neutral condition said processing unit including means for processing said input signals according to a predetermined program for determining the optimum clutch engagement starting position (CPO), and for issuing an output command signal (48) instructing a clutch operator (30) to move the clutch thereto, and said program including the steps of: storing a selected one of a predetermined or calculated clutch position increment (C3) in memory; retrieving from memory a previously stored value of the optimum clutch engagement start-

ing position (CPO);

comparing the retrieved optimum clutch engagement position (CPO) to a predetermined clutch position (C4) and, if less,

(i) initiating a calibration procedure by which the processing unit (12) issues a command signal (48) causing the clutch to engage slowly; and then determining whether the transmission input shaft speed ( $N_T$ ) is increasing and, if not, repeating the slow clutch engagement and, if yes, determining the specific clutch position (CP1) and then determining the optimum clutch engagement starting position (CPO) as the difference between the specific clutch position (CP1) and the selected one of the predetermined or calculated clutch position increment (C3) and then storing the determined optimum clutch engagement starting position (CPO); and, again comparing said (CPO) to predetermined clutch position (C4) and, if greater,

(ii) issuing a command signal (48) causing the clutch to engage rapidly and then determining whether the actual clutch position (CPA) is greater than the optimum clutch starting position (CPO) and, if not, repeating the rapid clutch engagement and, if yes, issuing a command signal (48) causing the clutch to engage slowly and then determining whether the transmission input shaft speed ( $N_T$ ) has increased and, if not, repeating the slow clutch engagement and, if yes, determining the specific clutch position (CP1) and then determining the optimum clutch engagement starting position (CPO) as the difference between the specific clutch position (CP1) and the selected one of predetermined or calculated clutch position increment (C3); determining a fractional relationship (C5) of the optimum clutch engagement starting position (CPO) to the previous optimum clutch engagement starting position (CPN); comparing fraction (C5) to a predetermined fraction less than 1 and;

(i) if less, calculating the optimum clutch engagement starting position (CPO) as the difference between specific clutch position (CP1) and the selected one of calculated and predetermined clutch position increment (C3) and storing said determined (CPO) value in memory; and  
(ii) if more, storing the value (C5) in memory as a fault code and then determining the optimum clutch engagement starting position (CPO) by multiplying said (CPO) by the quantity one minus a predetermined fraction (C6) that is less than one and then storing said determined (CPO) value.

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4. An automatic clutch control system (200) for optimizing the clutch engagement starting position for coupling a vehicle engine (2) to a transmission input shaft (5), said system (200) including an information processing unit (12) having means for receiving a plurality of input signals including (1) a signal (46) indicative of engine speed ( $N_E$ ); (2) a signal (52) indicative of actual clutch position (CPA); (3) a signal indicative of transmission input shaft speed ( $N_T$ ) and; (4) a signal (36) indicative of whether or not the transmission is in a neutral condition, said processing unit (12) including means for processing said input signals according to a predetermined program for determining the optimum clutch engagement starting position (CPO) and for issuing an output command signal (48) instructing a clutch operator (30) to move the clutch thereto, and said program including the steps of:

storing a selected one of a predetermined or calculated clutch position increment (C3) in memory;

retrieving from memory a previously stored value of the optimum clutch engagement starting position (CPN);

determining whether the transmission input shaft speed ( $N_T$ ) is less than a predetermined low speed (C7) and, if not, repeating the determination and, if yes, determining whether the optimum clutch engagement starting position (CPO) is greater than a predetermined clutch position (C4) and:

(i) if not, initiating a calibration procedure by which the processing unit issues a command signal causing the clutch to engage slowly and then determining whether the transmission input shaft speed ( $N_T$ ) is greater than the predetermined low speed (C7) and, if not, repeating the slow clutch engagement and, if yes, determining the specific clutch position (CP1) and determining the optimum clutch engagement starting position (CPO) as the difference between the specific clutch position (CP1) and the selected one of calculated or predetermined clutch position increment (C3) and then storing the determined optimum clutch engagement starting position (CPO) in memory and again comparing said (CPO) to predetermined clutch position (C4) and, if greater

(ii) issuing a command signal (48) causing the clutch to engage rapidly and determining whether the actual clutch position (CPA) is greater than the optimum clutch engagement starting position (CPO), and, if yes, issuing a command signal (48) causing the clutch to engage slowly and determining whether the transmission input shaft speed is greater than

the predetermined low speed (C7) and, if not, repeating the slow clutch engagement and, if yes, determining the actual clutch position (CP1) and determining the optimum clutch engagement starting position (CPO) as the difference between the specific clutch position (CP1) and the selected one of calculated or predetermined clutch position increment (C3); and then determining a fractional relationship (C5) of the optimum clutch engagement starting position (CPO) to the previous clutch engagement starting position (CPN);

comparing fraction (C5) to a predetermined fraction (C6) less than 1 and;

(i) if less, calculating the optimum clutch engagement starting position (CPO) as the difference between specific clutch position (CP1) and the selected one of calculated or predetermined clutch position increment (C3) and storing said determined (CPO) value in memory; and

(ii) if more, storing the value (C5) as a fault code and then determining the optimum clutch engagement starting position (CPO) by multiplying said (CPO) by the quantity one minus a predetermined fraction (C6) that is less than one and then storing said determined (CPO) value in memory.

5. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a predetermined value.

6. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a predetermined value plus a predetermined conversion factor multiplied times the temperature of the transmission oil.

7. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of the transmission input shaft speed.

8. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of the rate of change of the transmission input shaft speed.

9. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of rate of change of the clutch position.

10. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is a percent of the clutch incipient

torque position (CPO).

11. The system of claim 3 or 4 wherein the selected one of predetermined or calculated clutch position increment (C3) is equal to a predetermined value (C4) when the clutch Incipient torque position (CPO) is less than a predetermined value (C4).

12. An automatic clutch control system (200) for optimizing the clutch engagement starting position for coupling a vehicle engine (2) to a transmission input shaft (5), said system (200) including an information processing unit (12) having means for receiving a plurality of input signals including (1) a signal (46) indicative of engine speed, (2) a signal (56) indicative of actual clutch position, (3) a signal (42) indicative of transmission input shaft speed and, (4) a signal (36) indicative of whether or not the transmission is in a neutral position, said processing unit including means for processing said input signals according to a predetermined program for determining the optimum clutch engagement starting position and for issuing an output command signal (48) and said program including the step of an output command signal instructing a clutch operator (30) to move the clutch thereto, and said program including the step of engaging the clutch slowly in the event that the optimum clutch engagement value is less than a predetermined value until the transmission input shaft speed increases when the clutch position is measured.

13. The system of claim 12 wherein the measured clutch position is used to calculate a new optimum clutch engagement position.

14. The system of claim 12 wherein a selected one of a predetermined or calculated value (C3) is subtracted from the measured clutch position to determine a new optimum clutch engagement position.

15. An automatic clutch control system (200) for optimizing the clutch engagement starting position for coupling a vehicle engine (2) to a transmission input shaft (5), said system (200) including an information processing unit (12) having means for receiving a plurality of input signals including (1) a signal (48) indicative of engine speed, (2) a signal (52) indicative of actual clutch position, (3) a signal (42) indicative of transmission input shaft speed and, (4) a signal (36) indicative of whether or not the transmission is in a neutral position, said processing unit (12) including means for processing said input signals according to a predetermined program for determining the optimum clutch engagement starting position and for issuing an output command signal (48) and said program including the step of an output command signal instructing a clutch operator (30) to move the clutch thereto, and said program including the step of engaging the clutch slowly in the event that the optimum clutch engagement value is less than a predetermined value until the transmission input shaft speed increases above a predetermined value when the clutch position is increased.

16. The system of claim 15 wherein the measured clutch position is used to calculate a new optimum clutch engagement position.

17. The system of claim 15 wherein a selected one of a predetermined or calculated value (C3) is subtracted from the measured clutch position to determine a new optimum clutch engagement position.

18. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a predetermined value.

19. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a predetermined value plus a predetermined conversion factor multiplied times the temperature of the transmission oil.

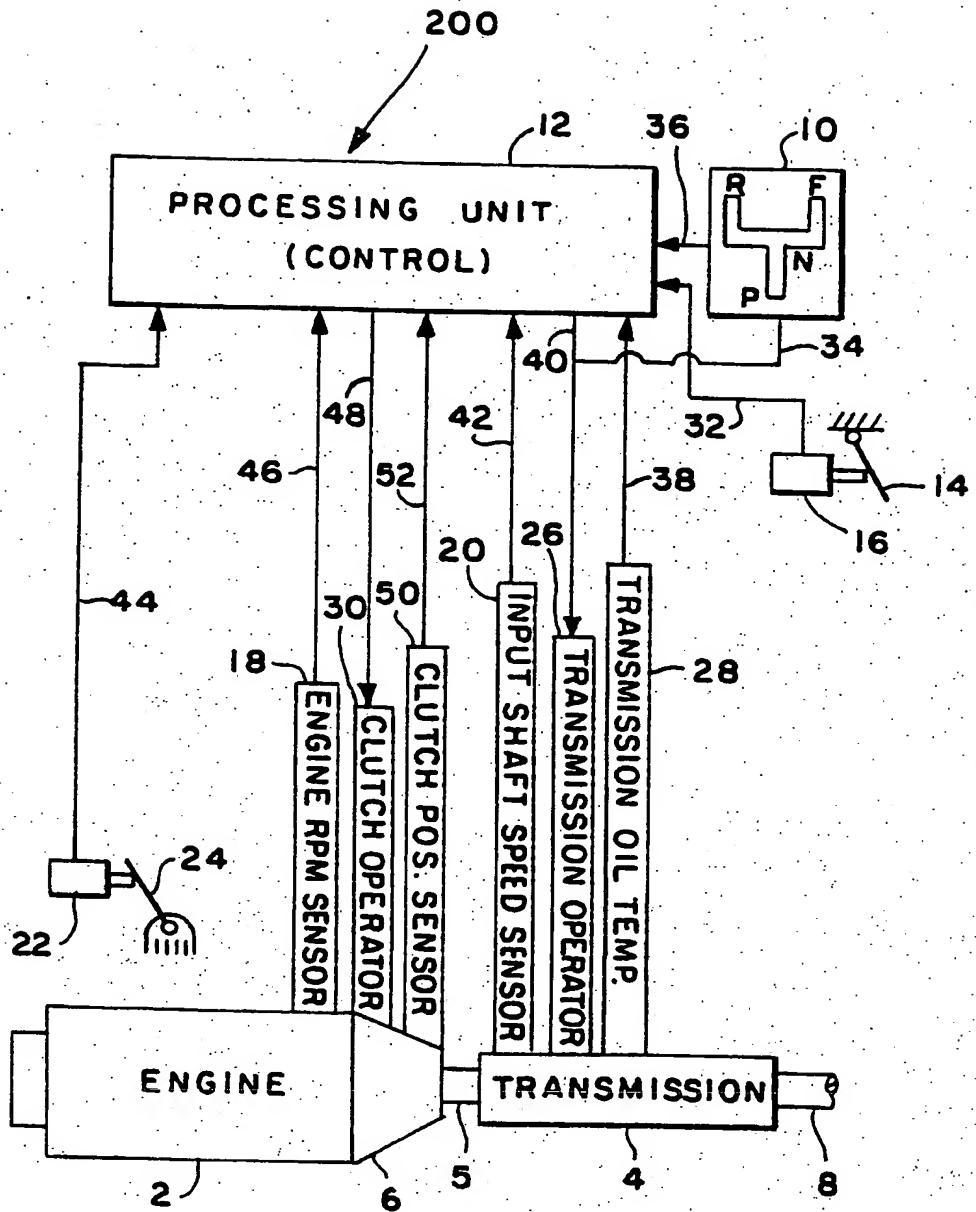
20. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of transmission input shaft speed.

21. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of the rate of change of the transmission input shaft speed.

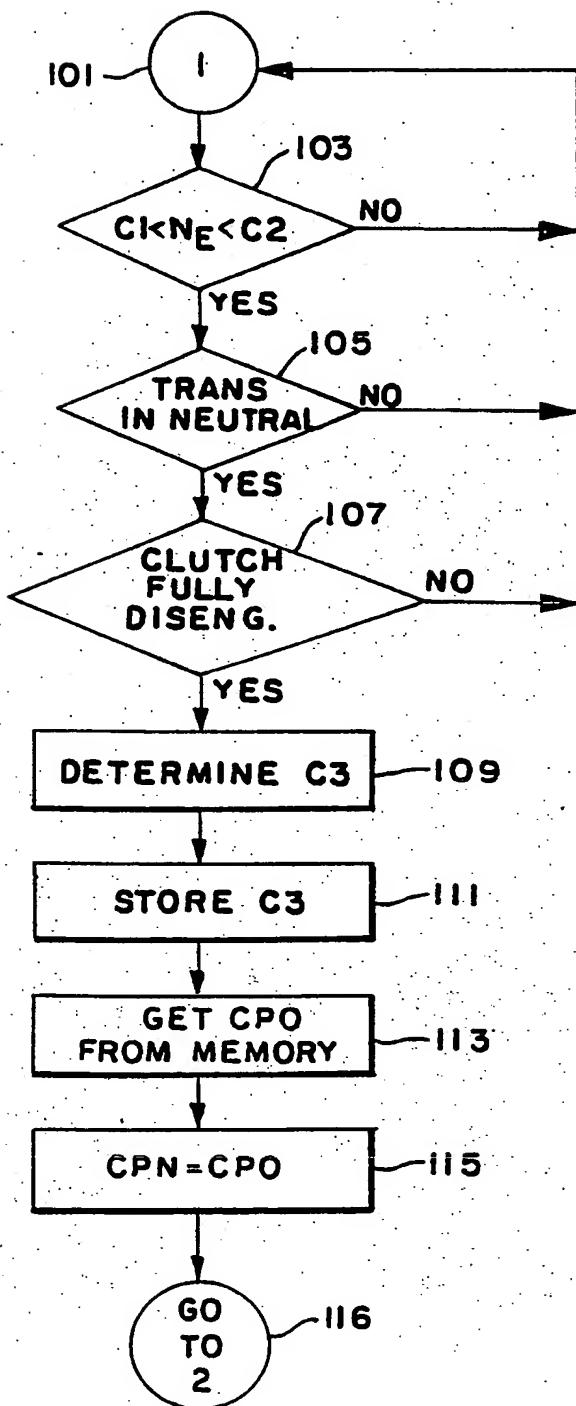
22. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a function of rate of change of clutch position.

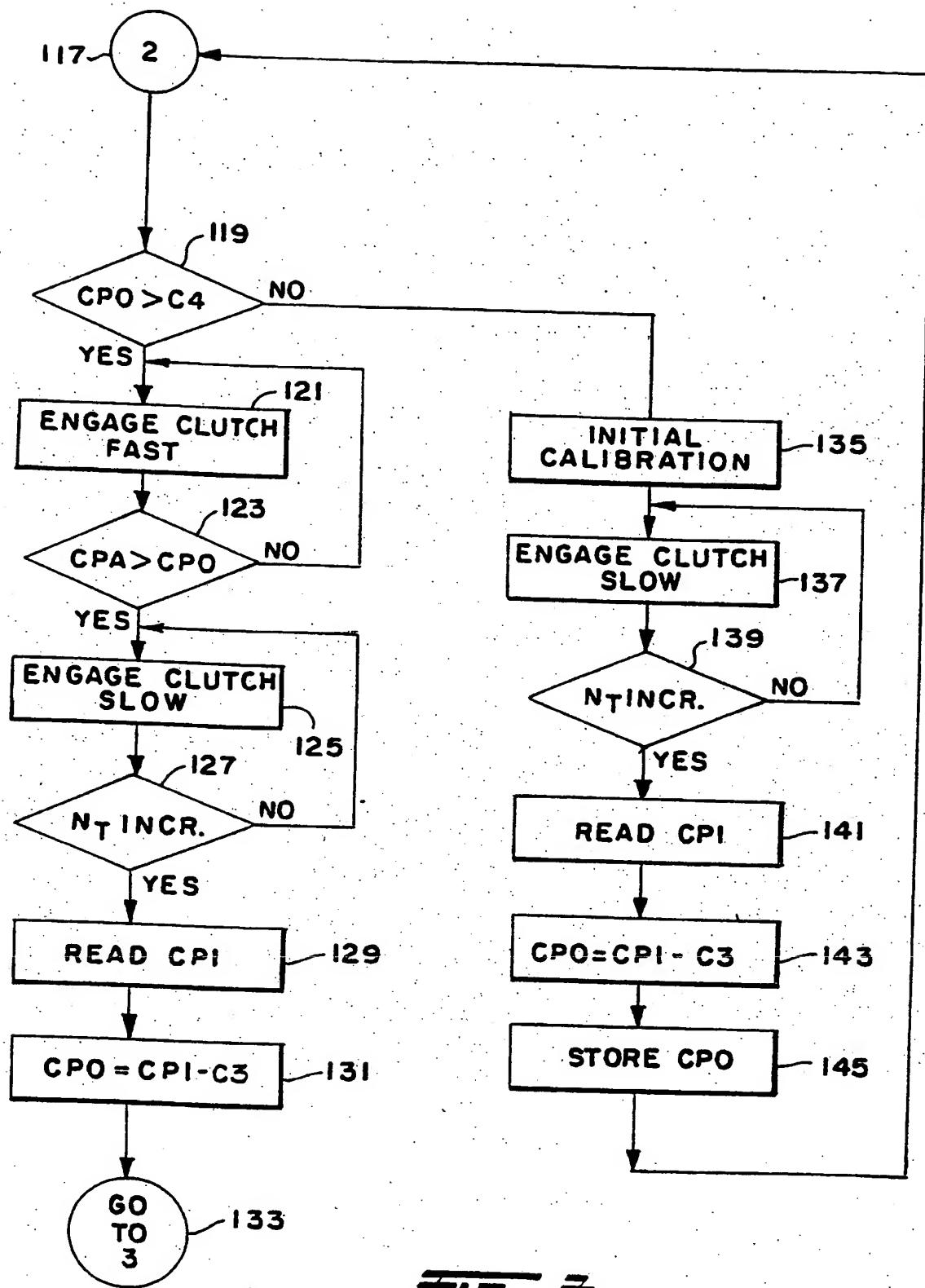
23. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is a percent of clutch incipient torque position (CPO).

24. The system of claim 14 or 17 wherein the selected one of predetermined or calculated clutch position increment (C3) is equal to a predetermined value (C4) when the clutch incipient torque position (CPO) is less than a predetermined value (C4).



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FIG. 2



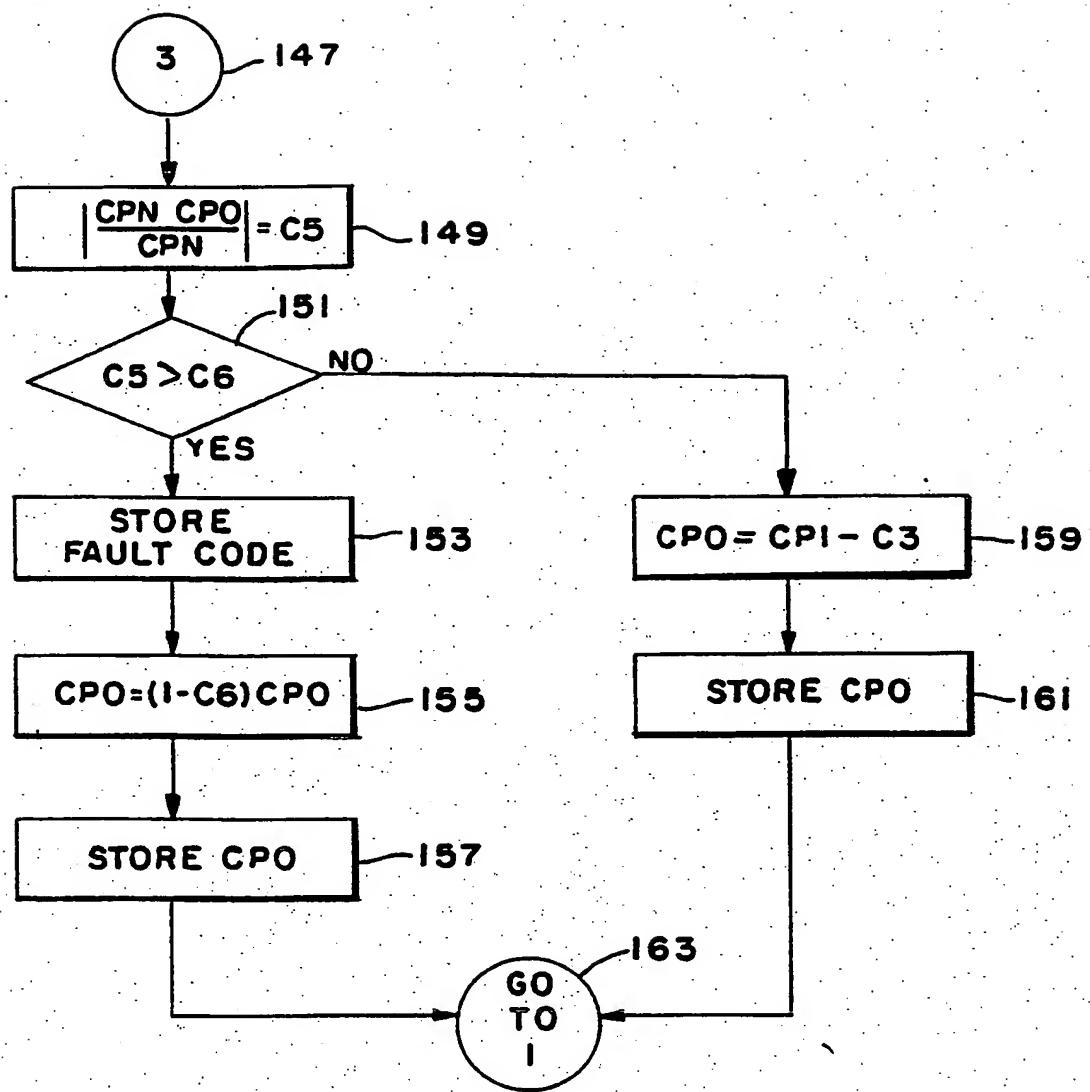
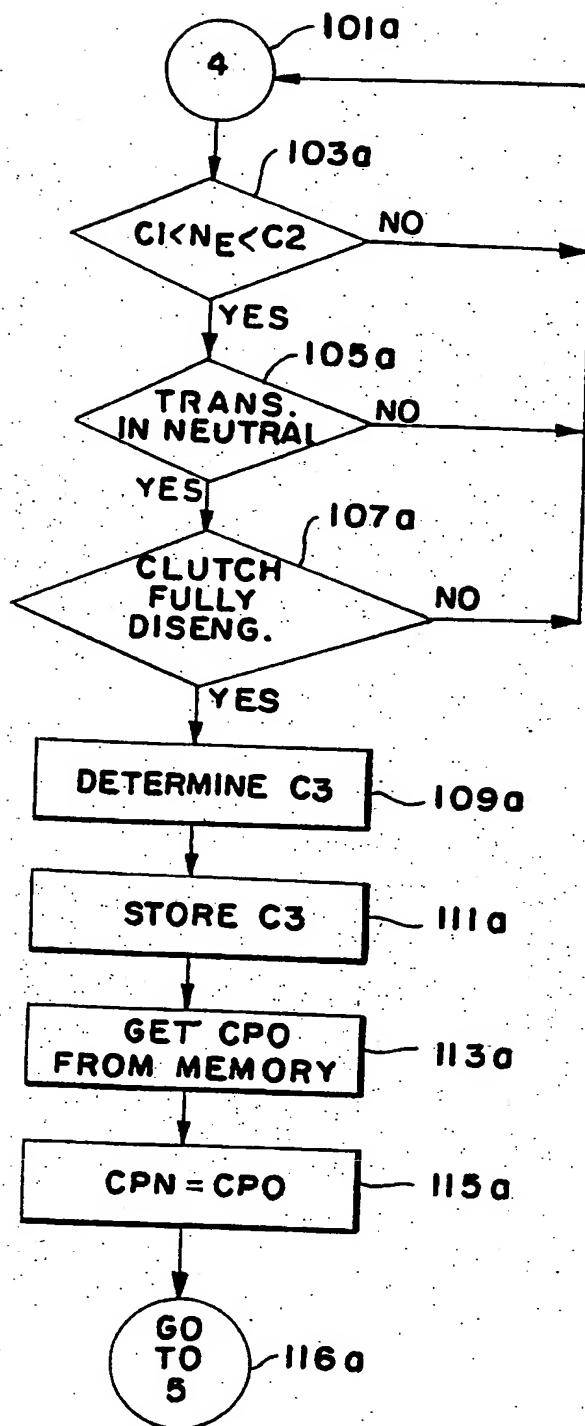


Fig. 4

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